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AN EXPERIMENTAL STUDY ON GFRC BY PARTIAL REPLACEMENT OF COARSE AGGREGATE WITH PUMICE STONE AND CEMENT WITH FLY ASH

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Abstract: - Now a days light weight aggregate concrete gained more importance than the normal conventional concrete due to its lesser density and high thermal conductivity. Glass fibre reinforced concrete is a composite material used to reduce the brittleness and increases ductility. Increasing utilization of light weight materials in structural applications is making pumice stone a very popular material. The addition of glass fibre to the light weight aggregate concrete gives better results than light weight concrete. In the present study coarse aggregate is replaced by pumice stone with 5%, 10%, 15%, and 20% along with optimum percentage (5%) of fly ash which is a replacement of cement. The optimum value obtained from these is considered and added with optimum percentage (1.5%) of glass fiber. The test results show that the density of light weight concrete decreases as increase in the percentage replacement by pumice stone. Compressive strength, split tensile strength and flexural strength results shows that the pumice stone replacement with 5% is the optimum value. Addition of glass fibre to the optimum mix shows that compressive strength, split tensile strength and flexural strength are increased by 14%, 17.5% and 19% respectively.
Keywords: Glass Fiber Reinforced Concrete (GFRC), pumice stone, Compressive strength, split tensile strength, and flexural strength.

1. INTRODUCTION

With the increasing amount of concrete used, natural environment and resources are excessively exploited. Synthetic light weight aggregate produced from environmental waste like fly ash, is a viable new source of structural aggregate material. The use of light weight concrete permits greater design flexibility and substantial cost savings, reduced dead load, improved cyclic loading, structural response, longer spans, better fire ratings, thinner sections, smaller size structural members, less reinforcing steel and lower foundations costs. Weight of light weight concrete decreases by 25% and 35% as compared to conventional concrete, but the strength is on par with Normal concrete.

Relatively small reduction in dead weight, particularly for members in flexure in high rise buildings, can save money and manpower in construction. In addition to reduction in dead weight, the lower modulus of elasticity and adequate ductility of light weight concrete may be advantageous in the seismic design of structures. Other advantages are greater fire resistance, low thermal conductivity, low coefficient of thermal expansion and lower erection and transport costs for prefabricated members.

Light Weight Aggregates may include Naturally occurring materials which require further processing such as expanded clay, shale, slate, vermiculite , pumice, foamed lava, volcanic tuff and porous lime stone and Industrial by-products such as sintered pulverized fuel ash (fly ash), foamed or expanded blast furnace slag, hemalite etc. Structural light weight concrete has an in-place density of 1440 - 1840 kg/m3compared to normal weight concrete with a density in the range of 2240 - 2500 kg/m3. There are other classes of non-structural light weight concretes with lower density made with other aggregate materials and higher air voids in the cement paste matrix, such as in cellular concrete. These are typically used for the insulation properties.

2. OBJECTIVE

To study the mechanical properties of the light weight concrete using pumice stone.

To study the mechanical properties of the light weight concrete with addition of the admixtures such as fly ash and glass fibre.

To accomplish the optimum percentage of the pumice stone.

To reduce the density of the concrete act as the light weight concrete by using pumice stone.

To increase the concrete strength by using the admixtures such as fly ash and glass fibre.

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3. EXPERIMENTAL WORK

The experimental investigation consists of casting and testing of 18 sets along with control mix. Each set comprises of 3 cubes, 3 cylinders and 3 prisms of standard dimensions for determining compressive, tensile and flexural strengths respectively. Pumice stone is used in the study with different percentages as a partial replacement to natural weight coarse aggregate and fly ash is used as replacement of cement with an optimum percentage. The optimum value obtained from these mixes is selected; glass fiber of specific percentage is added to find out hardened properties of concrete.

The constituent materials used in this study are Cement, Coarse Aggregate, Fine Aggregate, Fly Ash, Glass fiber and Pumice Stone (Light Weight Coarse Aggregate).

3.1 Cement –

The cement used was ordinary Portland cement of 53- grade conforming to IS 12269. The physical properties of the cement are tabulated below:

Table: 1 Physical properties of Ordinary Portland Cement

S. No	Property	Test Method	Test Results	IS Standard
1.	Normal Consistency	Vicat Apparatus (IS:4031 Part-4)	28.5%	Max limit- 30%
2.	Specific Gravity	Sp. Gr Bottle (IS:4031 Part-4)	3.10	3.15
3.	Initial Setting Time	Vicat Apparatus (IS:4031 Part-4)	53 minutes	Not less than 30 minutes
	Final Setting Time		493 Minutes	Not less than 10 hours
4.	Fineness	Sieve test on sieve no.9 (IS: 4031 Part -1)	5%	10%
5.	Soundness	Le-Chatlier method (IS: 4031 Part-3)	2mm	Not more than 10mm

3.2 Fine Aggregates –

The fine aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386 – 1963 and the material testing results are tabulated below.

3.3 Coarse Aggregates –

The normal maximum size is generally 16-20 mm; however particle sizes up to 40 mm or more have been used and the material testing results are tabulated below.

Table: 2 Physical properties of Coarse and Fine aggregate.

S. No	Property	Method	Fine Aggregates	Coarse Aggregates
1.	Specific Gravity	Pycnometer IS:2386 Part3-1986	2.65	2.85
2.	Bulk Density Loose Compacted	IS:2386 Part 3-1986	 1428 kg/m3 1580 kg/m3	 1651kg/m3 1896kg/m3
3.	Bulking	IS:2386 Part 3-1986	10% water	---
4.	Flakiness Index	(IS:2386 Part 2-1963)	---	8.08%
5.	Elongation Index	(IS:2386 Part 2-1963)	---	0%
6.	Fineness Modulus	Sieve Analysis (IS:2386 Part 2-1963)	3.18	6.04

3.4 Flyash –

The material testing results of fly ash used in the present investigation were given in below.

Table: 4 Physical requirements of fly ash

S.No	Physical properties	Test value	Specification limit as per (IS:3812-1981)
1	Specific gravity	2.55	---
2	Specific surface (cm2/gm)	3850	3200
3	Limit reactivity (Kg/ cm2)	52.5	40
4	Compressive strength at 28 days as percentage of strength of corresponding plain cement mortar cubes	86%	Not less than 80%
5	Soundness by Autoclave expansion	Nil	---
4	Fineness by sieving % passing 300 µ % passing 150 µ % passing 75 µ % passing 53 µ	 97.5 93.0 84.5 80.1	 --- --- --- ---

3.5 Glass Fibres (Gf) –

Glass fibre is a material consisting of numerous extremely fine fibers of glass. Glass fiber is formed when thin strands of silica-based or other formulation glass are extruded into many fibers with small diameters suitable for textile processing. Glass fibers are useful thermal insulators because of their high ratio of surface area to weight. However, the increased surface area makes them much more susceptible to chemical attack. By trapping air within them, blocks of glass fiber make good thermal insulation. The glass fibre is also used for thermal insulation, electrical insulation, sound insulation, high-strength fabrics or heat and corrosion resistant fabrics.

Fig: Glass Fibre

Table: 5 Physical Properties of Glass Fibres

Property	Value
Fibre tensile strength	3500 mpa
Industrial stand tensile strength	1700 mpa
Modulus of elasticity	72000 mpa
Fibre length	12 mm
Aspect ratio	857
Specific gravity	2.68
Strain fracture	2.4%
Fibre diameter	14 microns
Softening temperature	860˚c

3.6 Mix Design –

The mix design is done as per Indian standard code. The following are the obtained mix proportions

Mix proportion by weight:

Cement: FA: CA = 1: 0.983: 2.93 W/C = 0.4

Mix proportion by volume:

Cement: FA: CA = 1:0.91:2.83

Material required per cubic meter of concrete:

Cement(kg)	Sand(kg)	Coarse aggregate (kg)		Water(lt)
		20mm	10mm	
450	442.44	846.04	475.9	180

Mix design for each set having different combinations are carried out by using IS: 10262 - 1982 method. The mix proportion obtained for normal M40 grade concrete is 1:0.91:2.83 with a water-cement ratio of 0.40.

Tests on hardened concrete–

The compressive strength , Split tensile strength , flexural strength tests are conducted at 7 days, 28 days and 56 days curing.

4. EXPERIMENTAL RESULTS

The behaviors of specimens casted with varying proportions of light weight aggregate are given below:

Table 6: Compressive strengths at optimum percentage of fly ash

S. No	Mix designation	7 days (MPa)	28 days (MPa)	56 days (MPa)
1	M40 Control mix	35.46	48.26	49.42
2	M40 5% P + 5%FA	33.96	47.50	48.88
3	M40 10%P+ 5%FA	32.86	46.44	48.12
4	M40 15%P + 5%FA	31.88	45.70	47.00
5	M40 20%P + 5%FA	30.66	45.20	46.32

Table 7: Tensile strength at optimum percentage of fly ash

S. No	Mix designation	7 days (MPa)	28 days (MPa)	56 days (MPa)
1	M40 Control mix	2.955	6.03	6.44
2	M40 5% P + 5%FA	2.83	5.70	6.29
3	M40 10%P+ 5%FA	2.738	5.57	6.18
4	M40 15%P + 5%FA	2.656	5.52	6.07
5	M40 20%P + 5%FA	2.555	5.45	5.99

Table 8: Flexural strength at optimum percentage of fly ash

S. No	Mix designation	7 days (MPa)	28 days (MPa)	56 days (MPa)
1	M40 Control mix	4.2	7.45	7.67
2	M40 5% P + 5%FA	4.08	7.23	7.40
3	M40 10%P+ 5%FA	4.033	7.02	7.27
4	M40 15%P + 5%FA	3.91	6.92	7.15
5	M40 20%P + 5%FA	3.87	6.85	6.97

The behaviors of specimens casted with varying proportions of light weight aggregate with optimum percentage of glass fibre are given below:

Table 9: Compressive strengths at optimum percentage of fly ash and glass fiber

S. No	Mix designation	Compressive strength (MPa)
1	M40 5% P + 5%FA +1.5%GF	38.714(7 days)
2	M40 5% P + 5%FA+1.5%GF	54.15(28 days)
3	M40 5% P + 5%FA +1.5%GF	55.72(56 days)

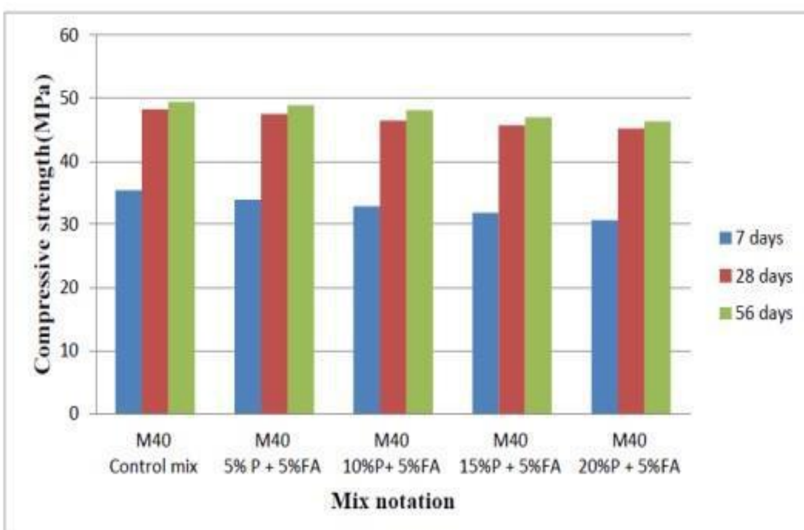
Table 10: Tensile strength at optimum percentage of fly ash and glass fiber

S. No	Mix designation	Tensile strength (MPa)
1	M40 5% P + 5%FA +1.5%GF	3.325(7 days)
2	M40 5% P + 5%FA+1.5%GF	6.69(28 days)
3	M40 5% P + 5%FA +1.5%GF	7.39(56 days)

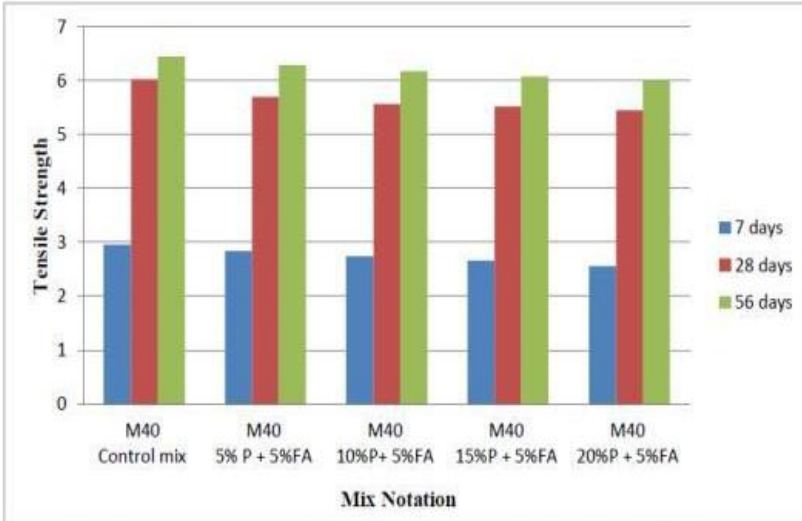
Table 11: Flexure strength at optimum percentage of fly ash and glass fiber

S No	Mix designation	Tensile strength (MPa)
1	M40 5% P + 5%FA +1.5%GF	4.85(7 days)
2	M40 5% P + 5%FA+1.5%GF	8.6(28 days)
3	M40 5% P + 5%FA +1.5%GF	8.88 (56 days)

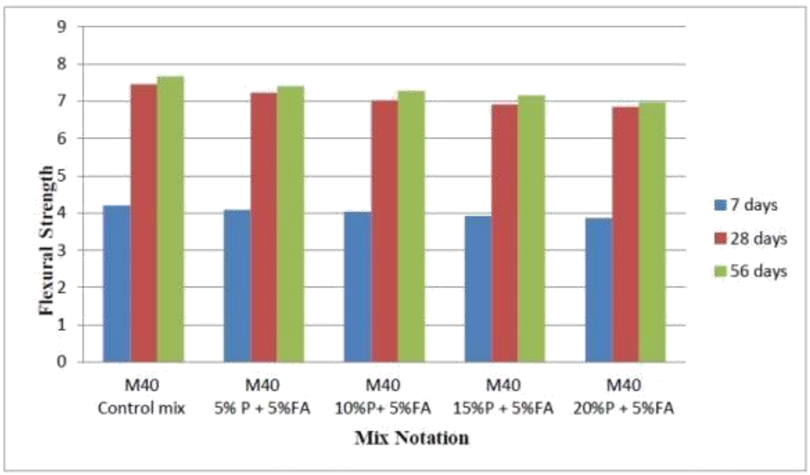
5. DISCUSSION OF TEST RESULTS:



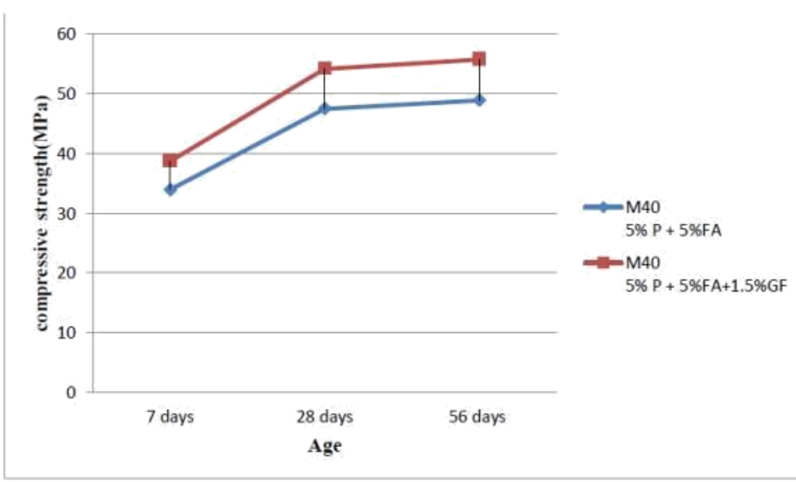
Graph representing compressive strength in MPa for 7, 28, 56 days with different mixes



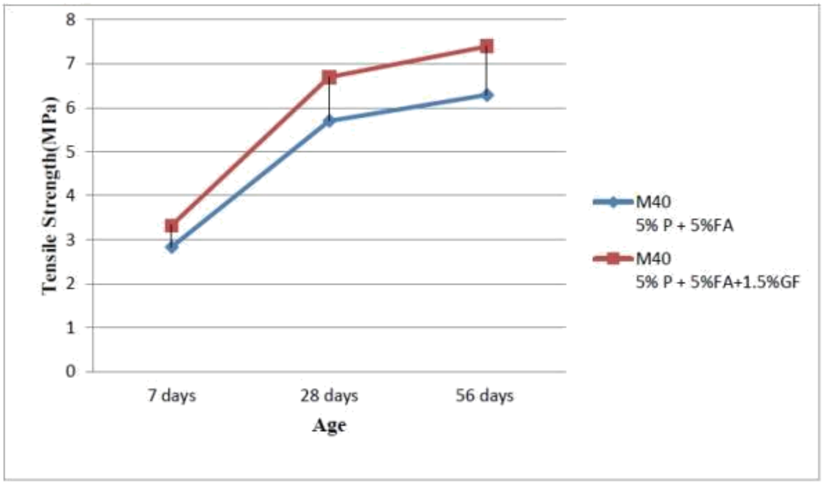
Graph representing tensile strength in MPa for 7, 28, 56 days with different mixes



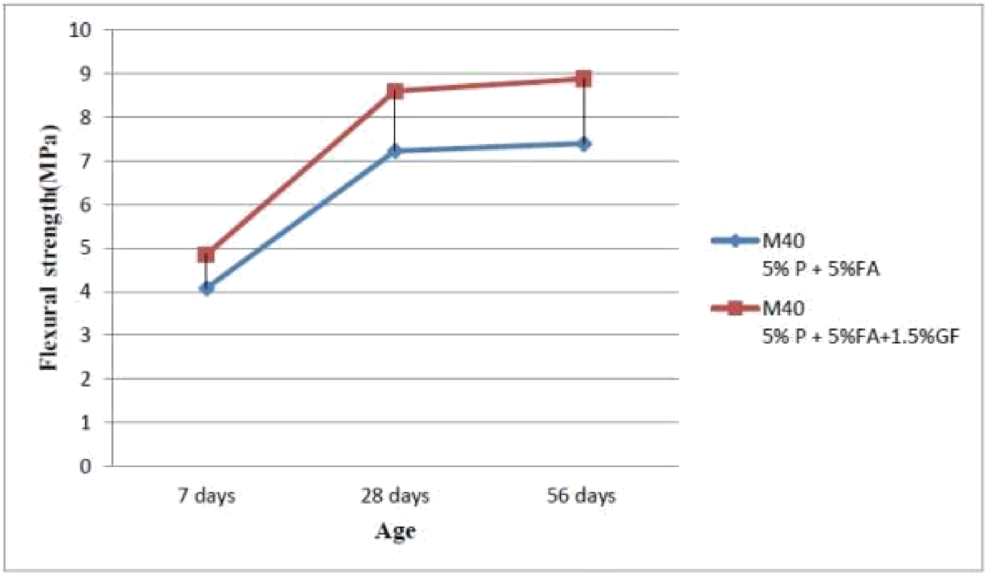
Graph representing flexural strength in MPa for 7, 28, 56 days with different mixes



Compressive strength with optimum percentage of fly ash and glass fiber



Tensile strength with addition of fly ash and glass fiber



Flexural strength with addition of fly ash and glass fiber

6. CONCLUSIONS

By using 5% pumice stone as a partial replacement to the natural coarse aggregates the compressive strength is promising.

The density of concrete is found to decrease with increase in percentage replacement of natural aggregate by pumice aggregate.

The compressive strength of concrete is found to decrease with increase in pumice content.

The light weight aggregate is no way inferior to natural coarse aggregate and it can be used for construction purpose.

When the glass fibre added to the optimum percentage of pumice stone, the slump value obtained is very less.

The compressive strength decreased 6.28% for 56 days strength when 20% pumice stone is added

The tensile strength decreased 6.98% for 56 days strength when 20% pumice stone is added.

The flexural strength decreased 9.12% for 56 days strength when 20% pumice stone is added.

Compressive strength increased 13.9% for 56 days strength when 5% pumice stone, 5% fly ash and 1.5% glass fiber is added.

Tensile strength increased 17.4% for 56 days strength when 5% pumice stone, 5% fly ash and 1.5% glass fibre.

Flexural strength increased to 20% for 56 days strength when 5% pumice stone, 5%fly ash and 1.5% glass fibre.

7. SCOPE OF THE FUTURE WORK

When trying with fly ash and glass fiber there are so many results which leads to good strength. The scope for this project is adding glass fibers to cement will shows very good result and gives good strength. In this project it has shown that optimum value yields better, but whereas for glass fibers yields better economy and gives unexpected strength in our country

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